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AN UNCONDITIONAL APPROACH TO CURTAIN WALL REPAIR

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This is the second installment of this article. The first installment summarized the typical failure mechanisms in curtain wall systems, the conventional repair approaches and a discussion of advantages and disadvantages of each repair approach. This installment is a case history on using the repair approaches outlined in the first installment.

The subject building is an eight-story office structure with a mechanical penthouse level on the top floor. It was built approximately 25 years prior to the repairs and the building facades along the south, east and west elevations are primarily clad with an aluminum-framed and glass curtain wall system. At the north elevation, the building facade consists of aluminum-framed and glass curtain wall along the ground level and the stair enclosure and precast panels with punched storefront window systems on the remainder of the facade.

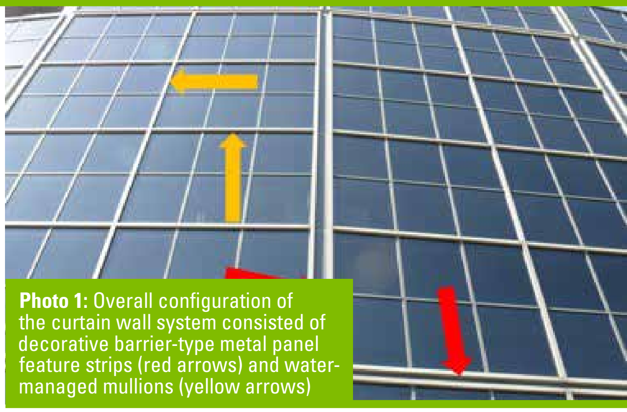

Photo 1: Overall configuration of the curtain wall system consisted of decorative barrier-type metal panel feature strips (red arrows) and water-managed mullions (yellow arrows)

Where the building is clad with a curtain wall system, the system consists of interior-set vision and spandrel glass panels. Glazing pockets at horizontal mullions have integrated internal drainage with end dams at the ends of

Photo 2: View of the building corner showing barrier-type metal panel cladding at corners (yellow arrow) and buttresses (red arrow). East and west elevations of the building also included HVAC

each mullion. The curtain wall system is segmented between column lines with a barrier type decorative metal cladding system separating the curtain wall panels (Photo 1). The joints in the barrier metal cladding are sealed with field-applied liquid sealant. On the east and west elevation of the penthouse level, large aluminum louvers serving the HVAC equipment have been integrated into the curtain wall system (Photo 2).

On the south elevation, the building columns extended above a setback terrace area forming decorative buttresses (Also Photo 2). These buttresses had been clad with a barrier type pre-finished aluminum cladding system.

The building had suffered from facade related water leaks since its original construction. The majority of the leaks were reported along the south and east elevations. The curtain wall related water leakage had been so pervasive that plastic buckets had been placed along vision glass sills throughout the building. After each rainstorm, the building engineering staff reported hundreds of leaks throughout the areas clad with the curtain wall system.

Photo 3: Typical deterioration of glazing gaskets

Photo 4: Open sealant joints at barrier metal cladding joints

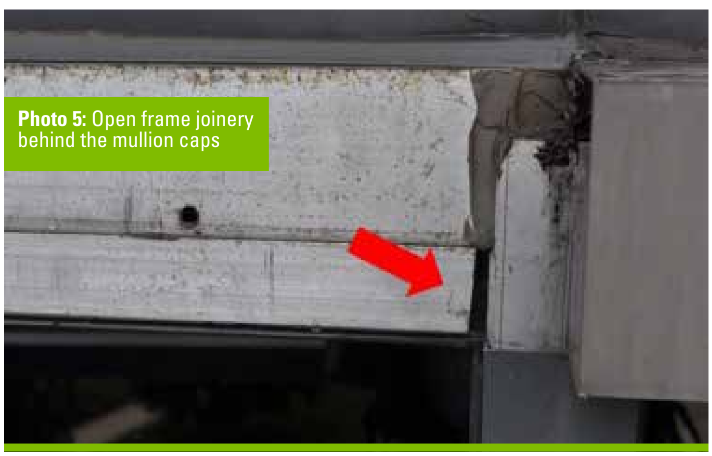

Photo 5: Open frame joinery behind the mullion caps

The building owner commissioned an evaluation of the water leakage issues. The scope of the investigation consisted of review of the curtain wall shop drawings, a visual review of the building exterior, water testing, removal of mullion caps to examine frame joinery, and preparation of a report.

The investigation revealed several issues associated with the curtain wall system. These included faded aluminum finishes, deteriorated glazing gaskets (Photo 3), deteriorated or open sealant joints at barrier metal cladding (Photo 4), inadequate internal seals, open frame joinery (Photo 5), displaced or rotated mullions, and extensive water leakage issues below the louver assemblies. In addition, dislodged and loose mullion caps were also observed at several locations. Extensive water leakage below the louvers was also confirmed through water testing.

REPAIR OPTIONS DEVELOPED FOR THE BUILDING OWNER

Based on the findings of the investigation, four repair options were developed for the owner's consideration. These repair options were as follows:

- **Option 1 – Surface Repairs**: This option consisted of removing the exposed portions of the glazing gaskets and applying sealant, replacement of sealant joints at barrier cladding system, and installation of custom molded silicone boots at mullion cap intersections.
- **Option 2 – Sealing Frame Joinery and Wet Sealing:** This option consisted of removing the exposed portions of the glazing gaskets and applying a cap seal, replacement of sealant joints at barrier cladding system, removing existing mullion caps to allow sealing of frame joinery, and providing new mullion caps. This option would provide for better aesthetics, improved durability, and improved reliability as compared to Option 1.
- **Option 3 – Retrofit with Custom-Extruded Components:** This option consisted of removing the existing mullion caps, installing a new custom-extruded pressure bar system over the existing frame, wet sealing perimeter of the glazing, providing a self-adhered air barrier over the existing barrier metal cladding, and over-cladding the metal cladding components with a drainable cladding system. This option would provide for better aesthetics, and improved durability and performance as compared to Option 2.
- **Option 4 – Complete Removal and Replacement:** This option consisted of complete removal and replacement of the curtain wall system. The advantages and disadvantages of the above options were discussed with the building owners on several occasions. The implementation of Option 4 would make it difficult to occupy the building during construction. Due to this and the cost of the replacement, this option was eliminated during early stages of discussions with the building owner. Of the remaining options, the advantages of Option 3 were most appealing to the building owner and they chose this option.

DESIGN OF REPAIRS

Figure 1 depicts the basic concept of Option 3 repairs at a typical horizontal mullion. The repairs would consist of trimming the exposed portions of the glazing gaskets, removing the existing snapped-on mullion caps, cleaning the frame surfaces, installing a custom-extruded aluminum pressure bar set in sealant, applying perimeter glazing sealant and installing a new custom-extruded pre-finished aluminum snapped-on cap. The new pressure bar would be 1/2

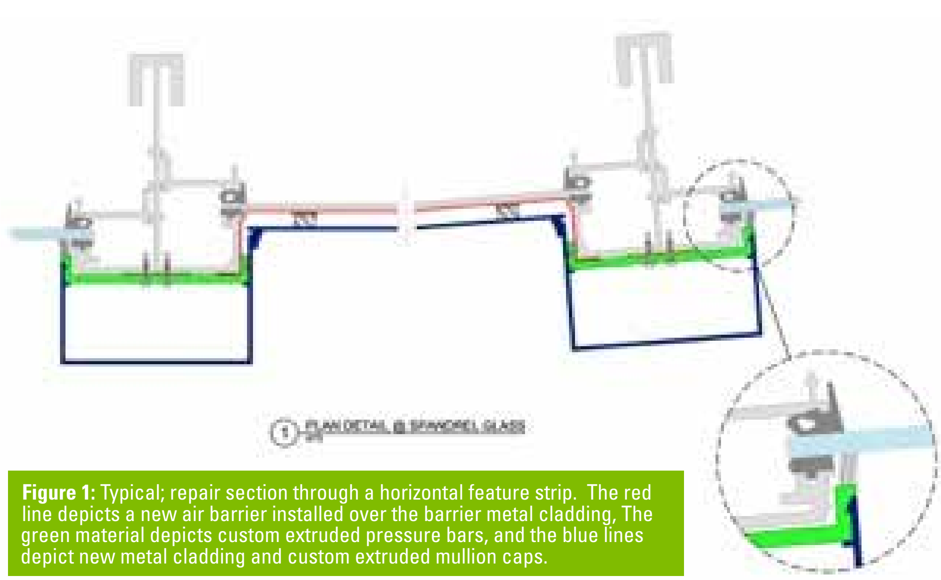

Figure 1: Typical; repair section through a horizontal feature strip. The red line depicts a new air barrier installed over the barrier metal cladding, The green material depicts custom extruded pressure bars, and the blue lines depict new metal cladding and custom extruded mullion caps.

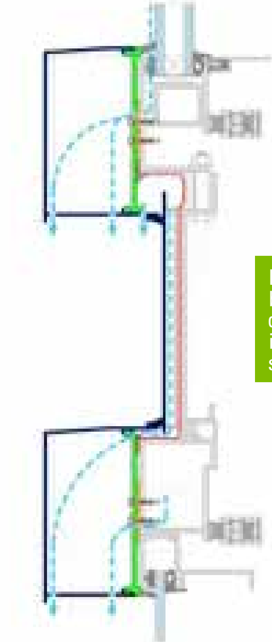

Figure 2: Light blue lines depict drainage path in the retrofitted system.

inch wider than the existing frame members allowing a glazing sealant depth of 1/4 inch. In addition, the new pressure bar sealant shoulder would be placed approximately 3/8 inch away from the exterior face of the IGU to allow for suitable sealant geometry. Such sealant geometry is far more reliable than a sealant cap bead typically used for wet seal repairs.

Once the new pressure bar was installed, weep holes would be drilled at the same locations as the existing weeps so that the internal water management of the system would function as originally intended.

Although the repair concept of Option 3 was relatively simple, adopting it to various details throughout the facade was challenging. These challenging details included the interface of the curtain wall at the barrier metal cladding areas, the configuration of the system at the HVAC louvers, and intersection of numerous extruded sections.

While these repairs would not address any of the internal seal issues within the system, they would provide for a reliable method of sealing the exterior face of the curtain wall system.

Figure 2 depicts the typical design detail at one of the horizontal decorative strips which originally consisted of a barrier type metal cladding system. At those locations, a self-adhesive air barrier would be installed over the existing metal cladding and terminated below the outer lips of the new curtain wall pressure bars. The new metal cladding panel would then be installed over a series of vertical aluminum spacer bars. These bars were designed to provide a drainage cavity between the new air barrier and the back of the new metal cladding panels. That cavity was designed to weep to the exterior through the horizontal mullion cover below each strip. In order to avoid fastening the new metal spacers and cladding through the air barrier, the design team opted to use structural tape to adhere the spacer bars to the back of the new metal cladding in the shop and structural glazing to adhere the assembly to the air barrier in the field. The sequence of repairs for the typical curtain wall section is shown in Figures 3a through 3j.

One of the challenges was selection of an appropriate air barrier which could resist the anticipated maximum temperature of 160 degrees F

Figure 3a Figure 3b Figure 3c Figure 3d Figure 3e Figure 3f Figure 3g Figure 3h Figure 3i Figure 3j

and be compatible with the structural glazing sealant used to attach the spacer bars to the air barrier. After researching available products, an aluminum-faced rubberized asphalt membrane with a maximum in-service temperature of 230 degrees F was selected for the project. The aluminum facing of the product would make the product compatible with the specified structural silicone glazing sealant. In order to provide redundancy for attachment of the new metal cladding panels, the new metal cladding strips were captured by the mechanically attached pressure bars, making it impossible for them to dislodge in the event the adhesive tapes or structural glazing failed.

Another challenge was the configuration of the HVAC louvers. Field testing had indicated extensive water leakage below the louvers. The interior of the louvers were either blanked off or directly connected to large ductwork. In order to ensure water management below the louvers, the louvers would have to be removed so that a pan flashing could be installed below them. The louvers had originally been installed from the interior: however, removal of the louvers would require removal of the interior ductwork which was deemed impractical. As such, it was decided to trim the exterior flanges of the vertical mullions to allow removal of the louvers from the exterior of the building. Once the flanges were trimmed, the louvers could be disconnected from the interior ductwork and removed. The design documents included an alternate to replace the louvers with new high-performance louvers.

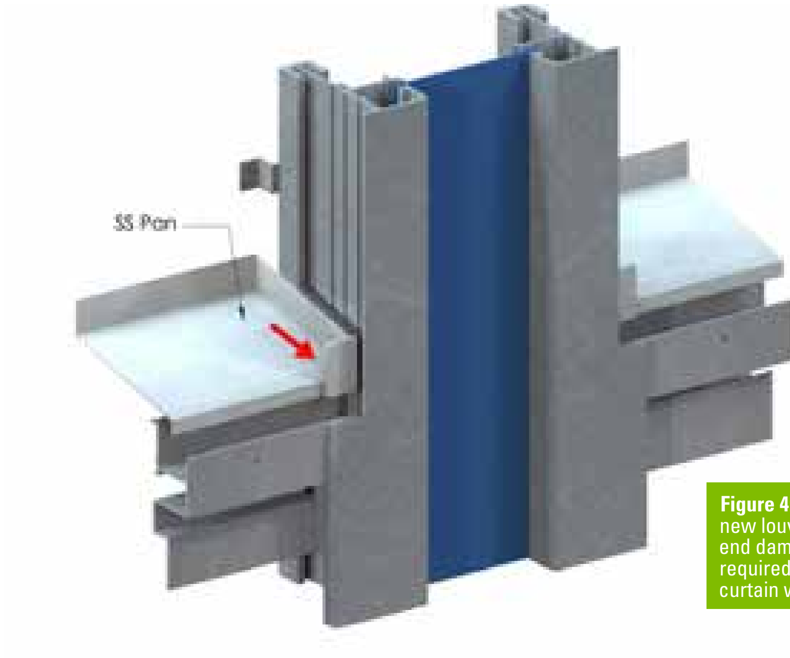

Figure 4: Stainless steel pan flashing below new louvers with a specially configured end dam. Red arrow depicts a welded tab required to divert water to the exterior of the curtain wall system.

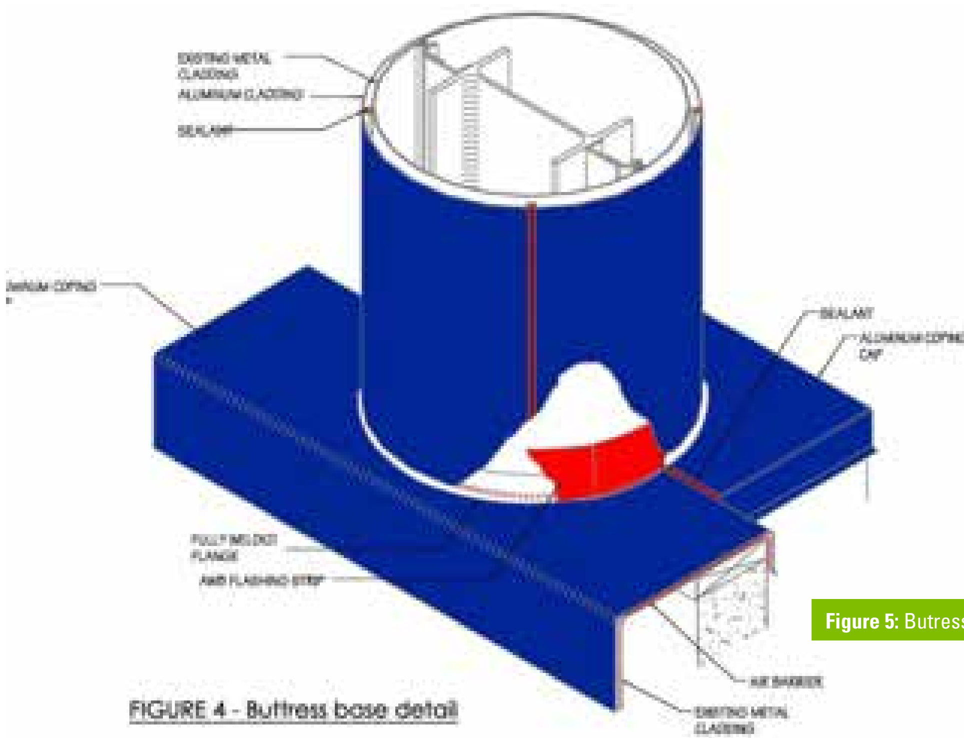

Figure 5: Butress base detal.

Due to the complex geometry of the new pressure bars, the louvers and their new pan flashing end dams, the louver assemblies and their surrounding curtain wall framing were modeled using 3D solid modeling software. This modeling allowed the design team to evaluate the sequence of work during construction and develop an appropriate end dam configuration for the louver pan flashing (Figure 4).

Figure 5 depicts the configuration of new metal cladding at the seventh floor terrace buttresses. The buttresses were treated similarly to other metal-clad areas by installing an air barrier over the existing cladding, installing spacer bars and installing new metal cladding over the

Photo 6: Pipe scaffolding at the terrace level used to support swingstage scaffolding.

Photo 7: Overall view of the mock-up areas

spacer bars. Care was taken to ensure the gap between the new and existing metal cladding was drained to the exterior.

All in all, the design required 19 custom-extruded profiles. Those profiles were carefully designed to provide for sealant geometry and grooves in the components to allow field technicians to properly locate fasteners. In addition to the custom-extruded profiles, many of the metal cladding components were to be custom fabricated and pre-finished. The specifications required pre-finishing of all exposed aluminum components using a fluoropolymer coating meeting requirements of AAMA 2605. The owners opted to maintain the original color scheme of the building. As such, custom colors matching the existing colors were specified for the aluminum finishes, as well as custom colors for the exposed sealant components.

BIDDING PHASE

One of the most significant challenges to the design team and the building owner was to identify qualified contractors with experience with similar projects who would be invited to bid the work.

The challenge was to convince those experienced contractors that this project would be a worthwhile endeavor. Due to the seemingly complex nature of the retrofit and involvement of custom extruded components, some of the originally identified contractors bowed out of the bidding process at early stages.

During the bidding phase, the design team presented a detailed description of the repairs and the methodology involved. Again, 3D modeling was used to depict the repairs in a step-by-step manner. Photos of prior projects using a similar approach were also used to familiarize the bidders with the repairs, and to set their minds at ease about practicality of the approach.

In all, four bidders were invited to bid and three of those four submitted a bid. Interviews were conducted with two of the three bidders. After careful consideration, the second lowest bidder was selected due to their understanding of the project.

CONSTRUCTION PHASE

The implementation of the repairs included re-sealing of precast panel joints on the north elevation of the building. Repairs spanned over two years and were performed in phases to minimize disruption to the building occupants. During the entire repair project, the building remained fully operational.

The implementation of the repairs posed many challenges for the project team. The first challenge was access to the building exterior. To facilitate access to most of the facade areas, the existing building scaffolding davits were tested and recertified.

This allowed the use of the building davit system to erect swing stage scaffolding over most of the facade. However, at the terrace areas, pipe scaffolding was installed to gain access to the building exterior (Photo 6). In addition, building entrances and entrance canopies were protected with temporary canopies.

The second challenge was to identify manufacturers and fabricators who could produce the custom-extruded profiles, fabricators who could fabricate the metal cladding components and finishers who could pre-finish all exposed metal components.

After selection of extrusion manufacturer, fabricator and a finisher, the contractor had to verify all field dimensions prior to submission of shop drawings and fabrication. Original erection of the curtain wall system had resulted in variations in standard daylight openings, making field measurement of each component necessary.

In order to ensure proper fit of all components and the ability of the repairs to resist water penetration, two in-place mock-ups were specified, one at a typical

Photo 8: Materials were stored in a warehouse space on the client's campus.

Photo 9: A color spectrophotometer was used to measure gloss and accuracy of color on prefinished panels.

curtain wall section including a decorative metal cladding strip, and one at a louver (Photo 7). Once the mock-ups were constructed, they were water tested by the design team to ensure they performed properly. The testing revealed no leaks through a section of the curtain wall which exhibited chronic leaks before the repairs.

After the mock-ups were evaluated, materials were ordered by the contractor. The lead time for some of the components included fabrication and finishing by two separate subcontractors, requiring shipment of components between multiple subcontractors. In some cases, the process took several months to complete. The materials were delivered to the site and stored in an indoor warehouse provided by the owners (Photo 8).

A preliminary review of the pre-finished components revealed inconsistent finish texture and gloss. This triggered a series of inspections and tests by the design team. The design team utilized a color spectrophotometer to quantitatively measure gloss of the finished components (Photo 9). The measured values were then compared to limits set by the specified standard (AAMA 2605) and the manufacturer's stated gloss value. The evaluation of the finishing gloss revealed that several curved panels were significantly out of the acceptable range of gloss. As such, those components were sent back to the finisher for re-finishing. During the repairs, the existing sign on the building which was attached to the terrace buttresses had to be changed to reflect the name and logo of the new parent company of the building owner. This change required modifications to the structural members that supported the sign and integration of those components with the new column and buttress cladding system.

The construction cost for the project was slightly less than $2,600,000. This cost included the complete re-sealing of all precast panel joints on the north elevation of the building, and installation of all new louvers on the east and west elevations of the building.

POST CONSTRUCTION

The project team closely monitored the performance of the repairs over several months after completion of the repairs. And, during the first few months after completion of the curtain wall repairs, a few localized leaks were reported by the building engineering staff. The locations and pattern of those leaks were carefully documented. Field inspection of the curtain wall at the affected areas and water testing revealed a few localized workmanship deficiencies which were promptly repaired by the contractor. Since those repairs, there has been no further leaks.

ABOUT THE AUTHOR

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Completed project.